Deployment of Diagnostics for Commercial Buildings: New Business Opportunities

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Introduction

Presently, HVAC equipment diagnostics is generally performed by service technicians responding to comfort complaints and using their experience to analyze data collected with hand tools. The effectiveness of the diagnoses and subsequent repairs is based on the technician's ability to restore comfort to the occupants. By improving this process, there are significant benefits to be realized, for example:

1. A fault detection system could identify problems before they result in comfort complaints.
2. Considering the operational history of the equipment leads to better diagnoses. Presently, only data collected while the technician is making the current repair is available to him.
3. Automated decision support tools make diagnoses more consistent throughout organizations, use less time, and raise the effectiveness of lower skilled technicians.
4. Logging and summary reporting of data provides for better management of the service process resulting in longer lasting repairs and higher operating efficiencies.

The HVAC industry is generally conservative and slow to try new technology. For good reason, since energy is relatively inexpensive. The benefits of new technologies are easily overshadowed by unreliable equipment. Helping to overcome industry reluctance, is the increasing cost and decreasing availability of skilled service technicians in today's marketplace. Furthermore, service providers are looking for ways to leverage relatively new information technologies to differentiate themselves from their competition. For this reason, we may see the following deployment of diagnostic technology:

1. **Portable tools for service technicians**
   Portable tools for service technicians offer the least risk and provide easily recognized improvements. They are the natural setting for the initial deployment of diagnostic tools because they are the smallest incremental improvement over current technique. It is the simplest fit into current business systems. Portable tools, with sensors that are moved with the tool, do not require significant capital investment dedicated to a particular piece of HVAC equipment. These tools will deploy from the simplest and least expensive models to the more complex and expensive.

2. **Field retrofitted proprietary monitoring and diagnostic tools**
   At the next level, proprietary monitoring and diagnostic tools will be retrofitted into equipment already operating in the field. The equipment, or a service using the equipment, will be sold directly to HVAC equipment owners. In the early stages, monitoring and diagnostics may be physically separated from the building and equipment controls to avoid blurring lines of responsibility. Facility managers and service contractors will use the monitoring and diagnostic tools. Internal equipment operating controls will still be provided by HVAC equipment manufacturers and building controls will be specified by energy managers. Dedicated monitoring and diagnostic tools may initially appear in more critical HVAC equipment applications where downtime is expensive (e.g. manufacturing plants versus retail stores).

3. **OEM installed proprietary monitoring and diagnostics tools**
   After HVAC equipment owners develop a significant appreciation for the benefits of monitoring and diagnostics, they will purchase the retrofit equipment and have it installed in the factory. This is how many rooftop unit building control systems are installed today. Eventually, these features may be provided by the equipment manufacturers and consolidated with the internal operating and building controls to reduce costs.

4. **OEM installed open protocol monitoring and diagnostic tools enhanced with 3rd party applications**
   As communication protocols solidify, the OEM tools will communicate with open protocols providing for large-scale integration into large building systems. A hierarchical environment will develop with 3rd party software applications providing enhanced features and integration.

New Business Opportunities

There are several new business opportunities revolving around the increased use of diagnostics and other information technology (IT) with HVAC equipment. The following is a list with specific references to Field Diagnostic's product line and its ACRx™ technology.

1. **Development and commercialization of FDD tools and technology**
   These technology development businesses sell hardware and software tools to other organizations that own or service HVAC equipment. Field Diagnostic Services, Inc. is an example of a business that develops and commercializes monitoring and diagnostic technology. Our customers are service contractors and corporate facility/energy managers.

Technology Example

The ACRx Handtool is designed to automate and increase the capability of service technician's hand tools. It replaces their traditional manifold gauges and digital thermometer with an integrated tool that

- Automates data acquisition
- Calculates performance indices (e.g. superheat, subcooling, coil splits)
- Provides front line decision support using diagnostics.
- Documents performance improvements.

The ACRx Servicetool is designed for short term monitoring of HVAC equipment to resolve difficult service problems, field test new HVAC equipment, and document equipment operating performance. It comes with weather-tight packaging, wireless communication for remote data access, and enhanced equipment safety controls providing flexible equipment protection.


The ACRx Controller is permanently installed and provides integrated building control and long term monitoring capability.



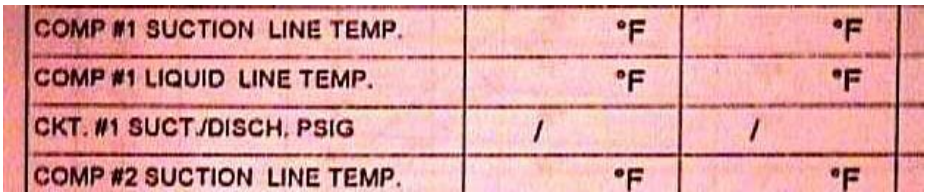
2. HVAC service contracting

Information technology and diagnostic tools provide new opportunities for HVAC service contractors to distinguish themselves from one another and become more cost effective. These tools provide the following features:

- Documentation of service effectiveness provides contractors and their customers with better service management tools.
- Diagnostic decision support makes the service product more uniform and raises the overall skill level of technicians.
- Short and long-term monitoring and subsequent data analysis provides higher quality and longer lasting repairs.

Technology Example

National retail chain facility managers and service contractors are using their own forms including excerpts like this to document the performance of HVAC equipment after spring startups and equipment repairs. Having technicians fill out these forms is expensive and difficult to accomplish reliably.



COMP #1 SUCTION LINE TEMP.	°F	°F
COMP #1 LIQUID LINE TEMP.	°F	°F
CKT. #1 SUCT./DISCH. PSIG	/	/
COMP #2 SUCTION LINE TEMP.	°F	°F

With the ACRx Handtool, the measurements are taken automatically and the following report can be printed or reported from a database on a web browser. The nomenclature is defined in the appendix.

ACRx		3/8/99 12:15 pm		
Sensors		Calculations		
SP	53	ET	29	Lo-
LP	232	SH	38	Hi++
ST	67	CT	112	Ok
LT	97	SC	15	Ok+
RA	76	CR	4.0	Ok
SA	50	ETD	26	Hi++
AMB	76	COA	36	Hi++
AOC	111	CTD	36	Hi++

Evaporator fan too fast.

Supporting evidence for Evaporator fan too fast is
SH is Hi++. COA is Hi++. CTD is Hi++. SC is Ok+.

3. HVAC field trouble shooting

There is a new business opportunity for service companies specializing in monitoring and trouble shooting.

- In the nearer term, while the installed base of monitoring equipment is small, they can ship them to remote sites where HVAC service contractors provide the installation. They collect and analyze data and help the service contractors resolve problems. This service is in higher demand when difficult situations occur such as multiple compressor replacements in a short period of time or many callbacks have still not solved the problem.
- In the longer term and even now in larger facilities, monitoring capabilities already exist. These service businesses, utilizing the latest data analysis and diagnostic tools, can help facility managers resolve operational problems and increase energy efficiency.

Technology Example

The ACRx Servicetool is used to solve difficult diagnostic problems. The following figures show the cycling pattern for a retail store unit in Vernon, CT. This information is provided to the service contractor and their technicians on their web browsers. The service technicians can view data and reports from their home PCs.

The left figure is the unit cycling on and off after the Servicetool was installed on 5/28/99. The solid portion of the bottom plot indicates the call-for-cooling. The top plot is the evaporator air temperature difference showing that the unit is operating. A few days latter (6/1/99) the oil failure tripped. The right figure shows the unsatisfied call-for-cooling. The top plots are the return and supply air temperatures. At 12 noon, the oil failure was reset and the unit turned on as indicated by the lower supply air temperature.

Here is a report emailed to the service technicians and their managers on a morning several days later. They receive it on their portable pagers with two-way email capability. The nomenclature is defined in the appendix.

The unit cycled normally for the past 24 hours. The building was probably comfortable yesterday. It is the second night that the thermostat has been enabled all night. The RA temperature is 67F at 7:30am this morning.

The longest runtime in the past 24 hours is 18 minutes and occurred at about 2pm yesterday. Here is how the unit is running:

SP	52	ET	28
LP	220	SH	34
ST	62	CT	108
LT	108	SC	0
RA	79	CR	-
SA	50	ETD	29
AMB	82	CTA	26
AOC	105	CTD	23
DT	131		

Here is the trend over the past few days:

Date	ET	SH	SC	ETD	AMB	RA
6/1 9pm	30	22	7	27	72	76
6/2 6pm	35	28	5	28	85	81
6/3 2pm	33	31	5	28	88	80

6/4 2pm	28	34	0	29	82	79

Increasing SH and decreasing SC raises concern about charge leakage. Look for an indoor airflow restriction causing the high ETD and low ET.

The monitoring and diagnostics enabled the service contractor to be extraordinarily competent in responding to a stressful situation caused by numerous callbacks and unresolved problems where occupants were chronically uncomfortable. These unresolved and recurring situations often result in customers switching to new service contractors to resolve the problem. Here is a message excerpt from the service contractor's operations manager showing that their customer appreciates the extra service.

> *The (service technician) spoke to (the customer) yesterday and he agreed that we should first examine the duct work and then start the process of replacing the unit. He is aware of the age and condition and thanked us for our efforts so far. It looks like we are going to replace the unit. The technician is already looking for a subcontractor.*

4. Monitoring and data warehousing services

There are companies developing new businesses to manage information associated with operating HVAC equipment, some examples are:

- There is a business that is helping manage service using an automated telephone system for data input from building occupants and service contractors. Facility managers monitor the progress of service work from their web browser.
- There are major companies that collect power consumption and equipment use patterns from remote sites. They provide reports to more effectively manage equipment operations.

Fault detection and diagnostic tools provide the tools to provide increasing value from data. As the tools are developed, these businesses will grow tremendously.

5. Integration into performance contracting

Performance contracting businesses provide cost saving products and services to clients and share in the demonstrated benefits of their efforts. It is common to provide energy saving upgrades such as replacing older equipment with new and more efficient models using the lower operating costs for payback. Monitoring and automated data analysis, including fault detection and diagnostics, has the potential to offer new cost saving opportunities for these businesses, including:

- Detecting when building controls are not set properly (e.g. 68F setpoints) and equipment that is not turning off during unoccupied periods.
- Detecting when air conditioning and refrigeration equipment have dirty heat exchangers or improper refrigerant levels causing a significant decrease in efficiency.
- Detecting when compressors operate in unsafe conditions leading to premature failure.

Appendix – Nomenclature

SP	suction pressure (psig)
LP	liquid pressure (psig)
ST	suction temperature (F)
LT	liquid temperature (F)
RA	return air temperature (F)
SA	supply air temperature (F)
AMB	outdoor ambient temperature (F)
AOC	air-off-condenser temperature (F)
DT	discharge temperature (F)
ET	evaporating temperature (F)
SH	suction line superheat (F)
CT	condensing temperature (F)
SC	liquid line subcooling (F)
CR	compression ratio
ETD	evaporator air temperature difference (F)
CTA	condensing temperature over ambient (F)
CTD	condenser air temperature difference (F)